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PRESERVATIVE TREATMENTS AND SERVICE LIFE OF FENCE POSTS IN PUERTO RICO

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RESUMEN

En Puerto Rico desde el 1944 se han estado investigando las técnicas de preservación de postes para cercas usando los métodos sin presión más económicos. Recientemente se han establecido estudios de campo y la mayor parte de los postes instalados tienen un servicio de 7 a 8 años. Los postes tratados por cuatro métodos sin presión y usando cinco agentes químicos han sido instalados en cuatro localizaciones de prueba. Los métodos usados son como sigue: (1) remojo frío, (2) remojo frío y caliente, (3) postes tratados verticalmente, y (4) postes tratados por doble difusión por los extremos. Los agentes químicos usados son: (1) creosota, (2) pentaclorofenol, (3) carbolina, y (4) dos combinaciones de sales en doble difusión. Alrededor de 6,000 postes tratados y sin tratar representando 70 especies están bajo estudio.

Este segundo informe de progreso que incluye todos los estudios llevados a cabo en este Instituto describe en detalle los materiales usados, métodos de tratamiento, retenciones químicas, terreno y clima en cada estudio y las condiciones de los postes hasta abril de 1967. Aunque la mayor parte de los postes ha estado en servicio por solo ocho años, hemos llegado a las siguientes conclusiones:

1. Los postes sin tratar tienen un promedio de vida útil de 1 1/2 años.

2. Los postes instalados en áreas de elevaciones altas tienen menos fallas que postes similares localizados en áreas de elevaciones bajas.

3. Aunque localmente el efecto de la polilla (los termes) es serio, la podredumbre causada por hongos es responsable de la mayor parte de las fallas.

4. Los postes tratados en una posición vertical con el tope hacia abajo por remojo frío en pentaclorofenol con aceite "diesel" absorben más preservativo que los postes tratados horizontalmente.

5. Los tratamientos de baño frío y caliente usando pentaclorofenol o creosota tienen a esta fecha, pocas fallas; la vida útil promedio de los postes tratados por estos métodos no se puede predecir exactamente pero los tratamientos similares usando carbolina indican que la vida útil debe ser 15 años o más.

6. Los postes tratados por el método de sales de doble difusión aplicado por inmersión completa del poste resultaron más durables que los postes tratados por difusión con el tope hacia abajo.

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SUMMARY

Low investment non-pressure wood preservation techniques for fence posts have been under investigation in Puerto Rico since 1944. Extensive field trials, however, have been established only recently and most of the test posts have been in service for 7 to 8 years. Posts treated by four non-pressure techniques (cold soaking, hot-and-cold bath, steeping, and end-diffusion) using five wood preservation chemicals (creosote, pentachlorophenol, carbolineum, and two double-diffusion salt combinations) are now set out at four test locations. About 6,000 treated and non-treated control posts representing 70 species are under study.

This second comprehensive progress report describes in some detail the materials used, treating methods, chemical retentions, soil and climate at each plot, and reviews the condition of the posts through the April 1967 inspection. Though most of the posts have been in service for only eight years, some tentative as well as final conclusions can now be made. They are: (1) untreated posts have an average service life of only 1.5 years; (2) treated posts set out at the high elevation plots have fewer failures than matched material placed near sea level; (3) although termite attack may be locally severe, decay fungi cause most of the failures; (4) posts cold-soaked in pentachlorophenol-diesel oil in a vertical position butt down had greater preservative solution absorption than those cold-soaked in a horizontal position; (5) hot-and-cold bath treatments using pentachlorophenol or creosote have, to date, few failures and average service life cannot be accurately predicted, but similar treatments using carbolineum indicate that the service life should be about 15 years or more; (6) posts treated with double diffusion salts applied by complete immersion are more durable than those treated by end-diffusion.

1/ In cooperation with the University of Puerto Rico.

INTRODUCTION

The potential benefits from the use of fence posts properly preserved against decay and termite activity have had little recognition in Puerto Rico. This can be attributed partially to the lack of knowledge concerning the treatability of local species using simple methods that could be readily applied by farmers, stockmen, and others.

The forest lands of Puerto Rico contain numerous species of trees in sizes suitable for fence posts and small poles. Except in a few mangrove areas, these trees are scattered over a large area with little or no concentration of any one species. Therefore, any useful evaluation of treatability and serviceability of local-grown woods must cover a large number of species. Results of such broad evaluations can lead silviculture toward the favoring of those species most suitable for preservation treatment.

At the present time there is a potential market for not less than one million treated posts per year. A small pressure plant could satisfy this need, but the high initial cost and the long-time effort required to develop consumer acceptance favored the study of low-investment non-pressure methods.

To help introduce good wood preservation practices, a demonstration test plot was first established by the Institute in 1944. Though very limited in scope, this early trial did show that long service life could be anticipated if a suitable chemical is properly applied by the hot-and-cold bath technique.

Extensive treating and evaluation trials were started in 1959-1960. Posts treated by four non-pressure techniques using five wood preservation chemical combinations are now set out at four test locations. About 6,000 treated and non-treated control posts representing 70 species are under study. Results of some of these treatability and durability studies have been reported by Englerth (9, 10) and Englerth and Goytía (11).

An initial all-inclusive report described in some detail the materials used, treating methods, chemical retentions, soil and climate at each plot, and reviewed the conditions of the posts up through the September 1963 inspection (8). This present report again describes these treatments and reviews the serviceability of the posts up through the April 1967 inspection. In addition, there is a brief description of a

new test installation established to evaluate the effectiveness of incising on service life.

These continuing wood preservation studies are based on the efforts of several present and former staff members and the authors gratefully acknowledge their contributions. The first hot-and-cold bath tests at the Institute were made in 1944 by J. Marrero and the 1952 coal soaking trials were established by M. A. Hernández Agosto. The posts in the 1959-1960 installations, which account for most of the tests under review in this report, were treated and set out under the supervision of G. H. Englerth with the assistance of E. Goytía Olmedo. Double diffusion results would have been of limited value without the generous cooperation and analytical work of R. H. Baechler, L. R. Gjovik, and R. F. Reinke of the Forest Products Laboratory (maintained at Madison, Wisconsin by the U.S.D.A. Forest Service in cooperation with the University of Wisconsin).

POSTS

In the comprehensive 1959 trials, 10 common Puerto Rican species were selected for cold soaking and hot-and-cold bath treatments using both pentachlorophenol and creosote. Nineteen additional species suitable for fence posts were treated with pentachlorophenol by both cold soaking and hot-and-cold bath. Twenty-six less common species were treated by cold soaking only, using pentachlorophenol. Thus, these and the other installations are representative of the available species growing to post size in the forests and plantations of Puerto Rico.

Most of the posts had top diameters of 2 to 3 inches, were 6 feet long, and consisted almost entirely of sapwood. A few posts included an appreciable amount of heartwood, and about 250 posts out of some 6,000 under study had other dimensions.

All of the posts were debarked before treatment and, except for the double-diffusion posts which were treated green, air-seasoned for 3 months or longer to a moisture content averaging about 18 percent. To minimize insect and fungus attack during seasoning, most of the posts were given an initial dip in a mixture of sodium pentachlorophenate and the gamma isomer of benzene hexachloride. The posts used in the 1952 installation were not given this pretreatment, and there was severe insect attack in some of the material.

The density of the posts under survey ranged from 17 to 59 pounds per cubic foot, averaging 42 pounds (based on the

air-dry weight and volume at approximately 18 percent moisture content). The very low density woods (less than 25 pounds per cubic foot) are:

achiotillo[1/]	tulipán africano
almácigo	yagrumo hembra
guacimilla	yagrumo macho

Extremely dense woods being evaluated in this study (about 55 pounds per cubic foot and over) are:

ausubo	casuarina
cacao motillo	cieneguillo
úcar	

PRESERVATIVES

Pentachlorophenol

Commercial grade pentachlorophenol concentrate was dissolved in a diesel oil carrier. A 10 percent solution (by weight) was used in the cold-soak treatment of posts installed at Cambalache and Toro Negro in 1952; all other "penta" treatments used a 5 percent solution. The properties of the oil carrier were as follows:

Specific gravity (A.P.I. 60°/60°F.)	32.7
Flash point (Pensky-Martens)	173°F.
Viscosity (S.U.S. at 100°F.)	37
Distillation:	
initial boiling point	386°F.
10 pct. recovery at	466°F.
50 pct. " "	524°F.
70 pct. " "	558°F.
90 pct. " "	618°F.
end point	620°F.
total recovery	99.5 pct.

The above analysis is representative of one batch of diesel oil (No.2-D Diesel fuel) used to make up the treating solutions and is believed to be typical of the oil solvent used throughout this study. This oil can be classified as a "Heavy Petroleum Solvent" and conforms to A.W.P.A. Standard P9-62 (1). In order to darken the oil and thus facilitate penetration measurements, 2 percent of No.6 fuel oil was blended with the diesel oil.

1/ Common and scientific names of all species mentioned are listed in the appendix.

Creosote

Commercial grade creosote conforming to A.W.P.A. Standard P1-54 (1) was blended with the oil described above to give a 50-50 (by volume) creosote-oil solution.

Carbolineum

The use of this preserving oil was limited to a few of the early studies. Distillation results of a carbolineum sample from the 1950 treatment were as follows:1/

Specific gravity at 38°/15.5°C.	1.090	
Moisture	0.1	pct.
Distilling up to 210°C.	0	pct.
235°C.	5.1	pct.
270°C.	26.4	pct.
315°C.	48.2	pct.
355°C.	75.5	pct.
Residue above 355°C.	24.0	pct.
Distillation loss	0.5	pct.
Total recovery	100	pct.

Specific gravity of distillation fractions at 38°/15.5°C.:

235°-315°C.	1.0447
315°-355°C.	1.1154

Generally the effectiveness of carbolineum as a wood preservative is similar to that of the coal-tar creosotes.(12)

Double diffusion salts

In these treatments two salt combinations were used. Combination FC (fluor copper) consisted of a 4 percent solution of sodium fluoride followed by a 7 percent solution of anhydrous copper sulfate. Combination CAC (copper arsenate chrome) consisted of a 10 percent anhydrous copper sulfate solution in the first stage and a mixture of 6.5 percent anhydrous sodium chromate and 6.5 percent anhydrous sodium arsenate in the second stage. All chemicals were technical grade and dissolved in tap water to the desired concentration.

TREATMENTS

Cold soaking, hot-and-cold, and double diffusion (steeping and end diffusion) methods were used in the treatments, and since these techniques have been described in detail

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1/ Analyses by R. H. Baechler, Forest Products Laboratory, Madison, Wisconsin.

elsewhere (2, 3, 4, 5, 6), only a brief review of procedure will be given.

Cold soaking

In the 1959 installation, the length, butt and top diameters, heartwood diameters (if present), and air-dry weights of each post were determined prior to treatment. To assure that sufficient seasoning had taken place, the moisture content of the posts was checked with a moisture meter. Batches of posts were then clamped horizontally in a carrying frame and submerged for 5 to 7 days in either the 5 percent pentachlorophenol or the 50-50 creosote-fuel oil solution. At the end of the treating time, posts were removed from the tank, allowed to drain, and reweighed.

Retention in pounds per cubic foot was determined for each post using the calculated volume and the pounds of preservative solution absorbed. Five to 11 posts of each species, representing low, average, and high retentions, were then cross-sectioned at 1-foot intervals along their lengths to determine average side penetration as a percentage of the sapwood radius.

In 1952 tests, the treating tank was two oil drums welded together and the posts were submerged vertically with the butt down in a 10 percent pentachlorophenol solution for a period of 5 days. Post volumes and retentions were determined as described above. No determinations of penetration were made.

Hot-and-cold bath

Posts in the 1959 trials were weighed, measured and treated in the same chemicals and concentrations as described for the 1959 cold-soak study. Posts were submerged horizontally in the preservative, maintained at about 200°F., for 2 to 15 hours and were then transferred to the cold tank treating solution for an additional 1 to 120 hours. At the end of their respective treating periods, the posts were removed from the cold tank, allowed to drain, and reweighed to determine the pounds of solution absorbed per cubic foot of wood (fig. 1). Schedules were varied according to the treatability of each species in order to obtain, if possible, a retention of about 8 pounds per cubic foot. Penetrations were then determined on sample posts, as described above for the cold-soak method.

These periods in the hot bath may cause a loss in moisture content of 5 to 10 percent, or more. Thus the retention values given in tables 6, 7, 8 are presumably somewhat lower than those actually obtained.

The 1944 and 1950 installations were treated with carbolineum. As in the other hot-and-cold bath treatments, posts

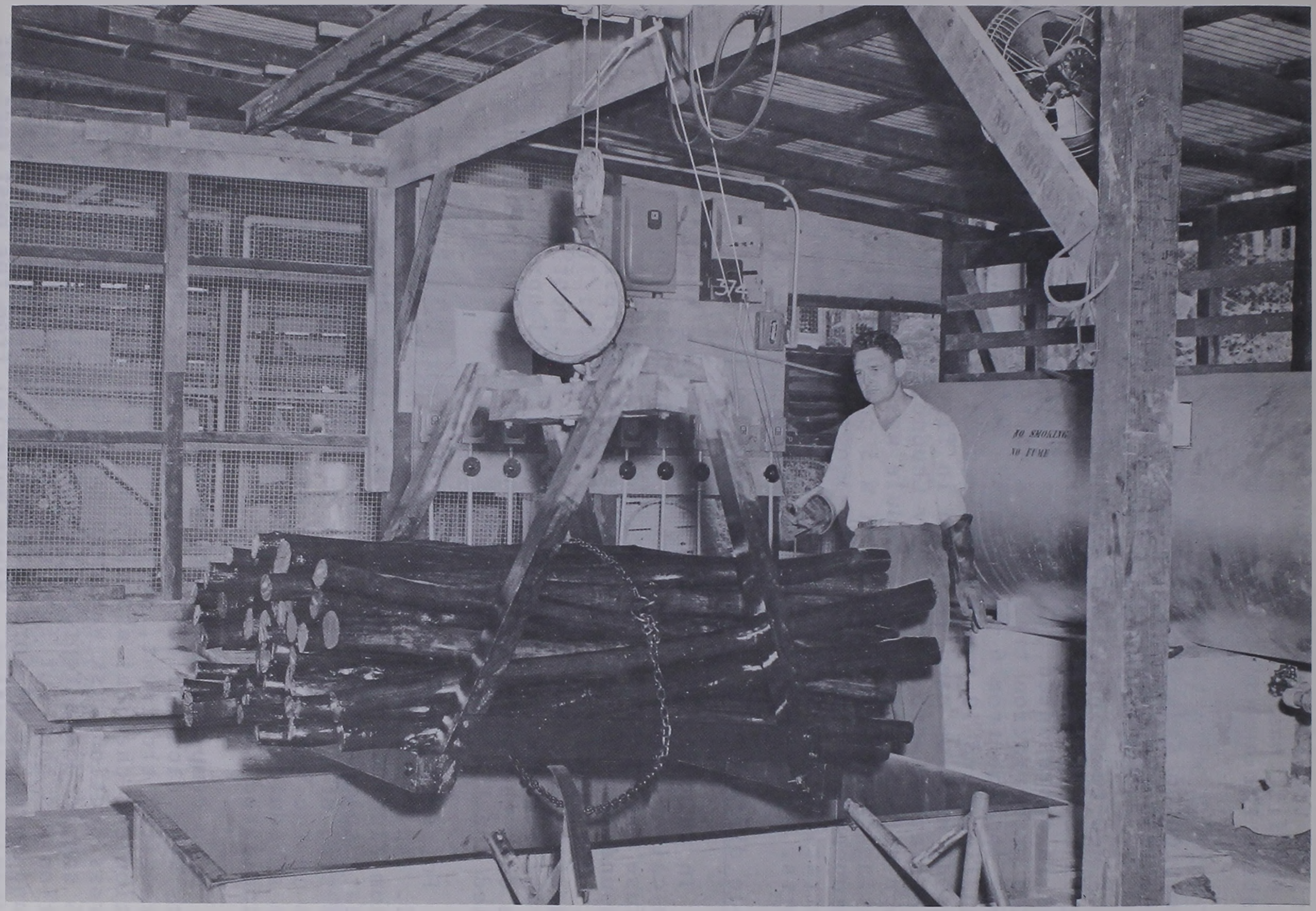

Figure 1.--General view of the experimental hot-and-cold bath treating plant. Posts are being weighed upon removal from the cold tank to determine retention.

were measured to determine volume and weighed before and after treatment to determine retention. Posts were heated in a barrel of preservative solution for 4 to 8 hours at 190-230°F.; then the fire was drawn and posts remained in the cooling preservative for an additional 13 to 18 hours.

Borings were taken from posts treated in 1944 for an estimation of side penetration, and a few posts representative of the 1950 treatments were sectioned for these measurements.

A new test installation to determine the effect of incising on service life was established in 1967. This service trial is represented by 20 posts for each of 18 species. Prior to the preservation treatment, 5 posts were incised full length, 5 were incised from 6 inches above to 18 inches below the groundline, and 10 posts were treated without incising. The incising machine used is shown in figure 2. Details of design and operation were reported by Chudnoff (7). A fixed 2 hour - 2 hour hot-and-cold bath schedule was applied to all posts. Treating chemical consisted of a 5 percent solution of pentachlorophenol dissolved in diesel oil. Chemical absorptions, penetration, and serviceability will be reviewed in subsequent reports.

Double diffusion

In this method green peeled posts are soaked first in one chemical solution and then in a second solution. The chemicals diffuse into the wood and react with each other to form a toxic compound that is relatively insoluble and resistant to leaching. The posts were treated by two methods: (1) complete immersion in tanks, called the "tank treatment" (T), and (2) end steeping, in which posts are stood upright in a barrel with only the butts in contact with the treating solution, called the "barrel treatment" (B).

For each treating method two chemical combinations were used. In Combination FC the posts were first treated with the sodium fluoride solution for 3 days, then held in the copper sulfate solution for an additional 3 days. Combination CAC consisted of 2 days in copper sulfate solution followed by 2 days in the mixture of sodium arsenate and sodium chromate. Time schedules for some of the species were modified and are so indicated in table 9.

Upon completion of each double diffusion treatment, the posts were close-piled for several weeks. Not less than 8 weeks after treatment, posts were sampled to determine penetration and chemical absorption. From tank-treated material a cross section disk was removed from the mid-length of each of 5 sample posts representing each species. A 1/4-inch thick section was then cut from each disk and the five sections were ground together to form a composite sample for determination of chemical retention. Since material from the post ends was

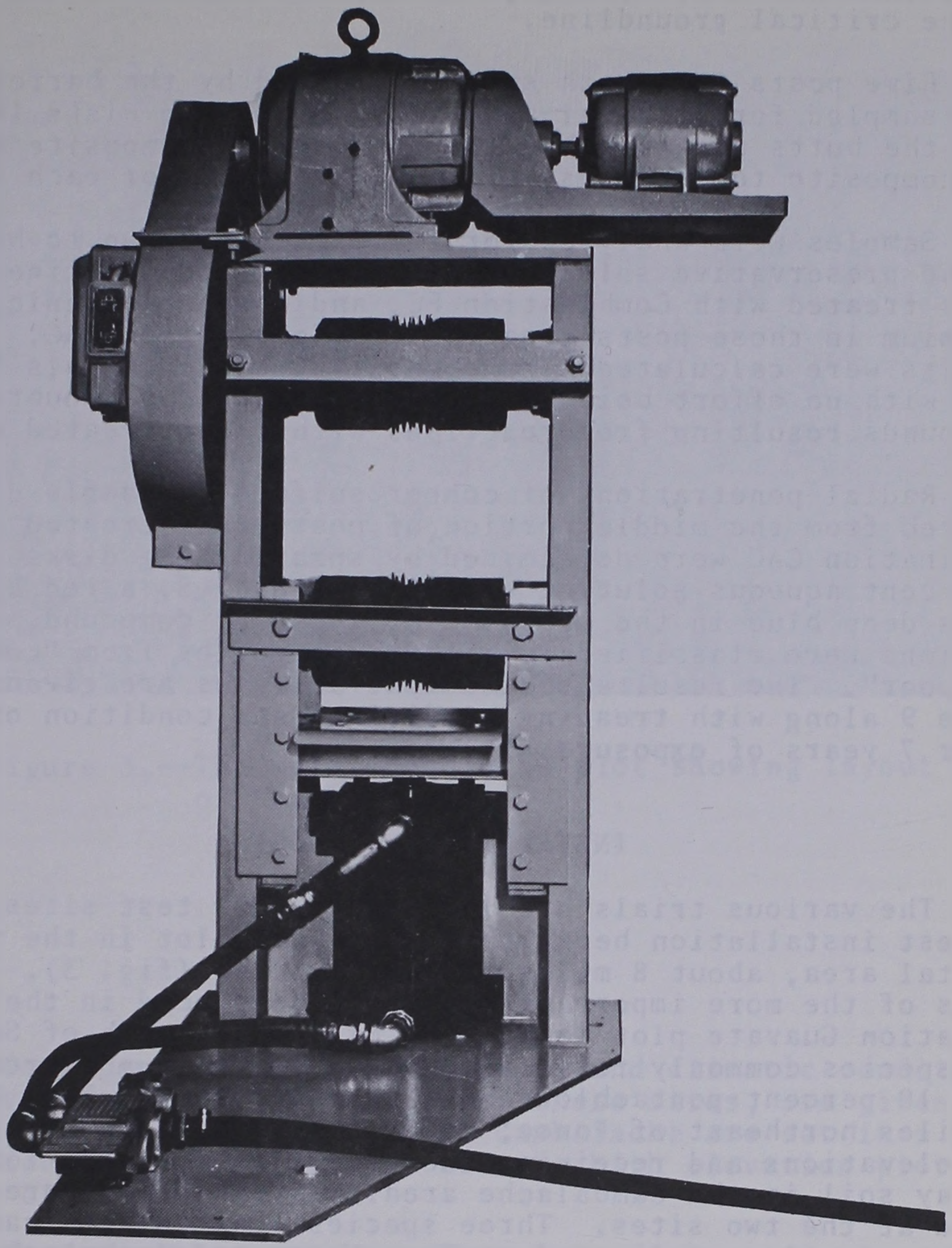

Figure 2.--Post incising machine designed at the Institute of Tropical Forestry showing all-motor type gear reducer, drums, and two-way piston in the "down" position.

not sampled, it is recognized that the results are somewhat lower than the true average, but they do represent retention at the critical groundline.

Five posts from each species treated by the barrel method were sampled for chemical analysis by removing disks 18 inches from the butts and 6 inches from the tops. Composite groundline and composite top samples were then prepared for each species.

Samples were analyzed for the elements known to be present in the preservative solution, i.e. copper and fluorine in those posts treated with Combination FC, and copper, arsenic, and chromium in those posts treated with Combination CAC. The results were calculated to the basis of the chemicals initially used with no effort being made to calculate the amounts of the compounds resulting from reactions within the treated wood.

Radial penetrations of copper sulfate in sample disks removed from the middle portion of posts tank-treated with Combination CAC were determined by spraying the disks with a 1 percent aqueous solution of Chrome Azurol S, a red dye which turns deep blue in the presence of a copper compound. Penetrations were classified into four categories from "complete" to "poor". The results of chemical analyses are given in table 9 along with treating conditions and condition of posts after 7 years of exposure.

INSTALLATION OF POSTS

The various trials are located at four test sites, the largest installation being the Cambalache plot in the northern coastal area, about 8 miles east of Arecibo (fig. 3). Replicates of the more important species were placed in the high-elevation Guavate plot located 23 miles due south of San Juan. The species commonly found in mountain terrain and treated with 10 percent pentachlorophenol are located at Toro Negro, 14 miles northeast of Ponce; other post species growing at low elevations and receiving the same treatment are located on a clay soil in the Cambalache area. Seven species are replicated at the two sites. Three species treated with carbolineum are also replicated at Toro Negro and Cambalache. Several casuarina posts treated with carbolineum have been set out at El Verde, 4 miles south of Río Grande. With few exceptions, untreated posts of each species were installed at each test site.

Figure 3.--The main Cambalache plot showing layout of the test plots.

Data concerning soil, geology, and climatic conditions, believed to be representative of these sites, are given in table 1. Most of the posts at Cambalache are set in a sandy clay loam, and the soils at all the high elevation plots are heavy clays.

Almost all of the posts are set out in randomized blocks and were generally spaced 36 inches within and between rows. The 6-foot posts were installed with their butts 18 inches in the ground, and post stubs were set 12 inches in the soil.

For the 1959-1960 installations there are generally 20 replications per species per treatment at each site except that posts treated by double diffusion using the barrel method have 10 replicates or less. Replications of posts treated with 10 percent pentachlorophenol and carbolineum are variable, ranging from only 2 for some species up to 12 for others.

All posts are identifiable by coded metal tags, and detail maps showing plot locations and post locations within plots were made for reference.

INSPECTION

Posts are inspected annually and tested to determine current serviceability by applying a firm lateral push at the tops. If the post breaks, cause of failure is determined, i.e. fungi or termite activity or both.

The average service life of posts receiving any particular treatment is then determined from mortality curves developed by MacLean (13) and is defined as that period when 60 percent of the posts have failed. Predictions of service life are calculated only for those treatments having 10 percent or more failures. Less failures provide an unreliable basis for use of the curves. Some of these predictions may be modified in future reports, but the data for average service life in tables 2 - 9 for post treatments having 60 percent or more failures are final.

RESULTS TO DATE

Data on treating conditions, chemical retentions, and serviceability are presented in tables 2 - 9. A discussion of these results is given below:

Untreated control posts (table 2)

Of 1382 untreated posts set in the ground 7 to 8 years ago, 4 percent are still serviceable, 60 percent have been destroyed by decay, 35 percent have failed because of combined decay and termite attack, and less than 1 percent has been destroyed by termite attack alone.

Average service life of all species is about 1.5 years (in 1.5 years we can expect 60 percent failure), but individual species vary from 0.4 to more than 11 years. The longer life of some of the species, e.g. capá blanco, tachuelo, and tea can be attributed to the presence of a large volume of durable heartwood.

For the 10 species common to both sites, average service life at Cambalache is 1.4 years and at Guavate 1.5 years. A comparison of percentage failures after only one year of service life showed that there have been 42 percent removals at Cambalache and 31 percent at Guavate. Though it appears that conditions for rot in untreated posts are slightly more favorable in the low-land plot, these differences are not statistically significant.

Cold-soak in 5 percent pentachlorophenol in diesel oil (table 3)

The 5-day cold-soak resulted in retentions that varied with species from .8 to 10.1 pounds of preservative solution per cubic foot. Side penetration also varied considerably, ranging from 0.1 to 1.4 inches or from 5 to 100 percent of the sapwood radius.

The following species can be classified as having moderately good retention and penetration when treated by this cold-soak method (retention of at least 4 pounds per cubic foot and over 50 percent sapwood penetration):

achiotillo	caimitillo
almácigo	casuarina
cacao motillo	mantequero·
caimitillo verde	sabinón
yagrumo hembra	

Of 1279 posts installed at both plots in 1959, only 33 percent are still serviceable after 8 years, 49 percent have been destroyed by decay, 17 percent by fungi and termite attack, and about 1 percent by termite activity.

Of the 55 species located at Cambalache 53 have sufficient failures for prediction of service life. This ranges from 3 to 12 years, averaging about 6.8 years. For the 10 species located at both sites, 71 percent of the posts failed at Cambalache but only 49 percent failed at Guavate. Average retention of the two groups was almost identical, 3.9 and 4.1 pounds of preservative solution per cubic foot respectively.

At the high-hazard Cambalache plot achiotillo, cacao motillo, caimitillo, caimitillo verde, capá blanco, granadillo, péndula, roble, and sabinón have a predicted service life of 10 years or longer. The underlined species were most receptive to this cold soaking treatment. In contrast, almácigo, casuarina, mantequero, and yagrumo hembra had a tolerable absorption and penetration (4 lb. per cu.ft. and 50 percent respectively) but have an average service life of only 5.2 years.

A 5-day cold-soak in the 5 percent pentachlorophenol in diesel oil can extend the average service life of posts from 1.5 years to about 7 years.

All failures to date have been at the groundline. We should expect some vulnerability in the tops of these posts, particularly in those species having very low absorptions, i.e. less than 2 pounds per cubic foot. This has not been the case. Of 492 posts still available for observation at the Cambalache plot (including posts that have been removed

during previous inspections and were laying on the ground) only 4 posts had moderate to severe decay in the tops. All the others were sound.

Cold-soak in 50-50 creosote-diesel oil (table 4)

The 5- to 7-day cold-soak in the mixture of creosote and diesel oil resulted in species retentions of 1.6 to 5.4 pounds per cubic foot, averaging 4.0 pounds. Side penetration varied from 11 to 60 percent of the sapwood radius.

Of 397 posts installed at both plots (Cambalache and Guavate) 256 or 64 percent are still serviceable after 8 years. Thirty percent have been destroyed by decay, 6 percent have failed due to combined decay and insect attack. No posts were lost due to termite attack alone.

Failures at Cambalache have amounted to 40 percent of those installed as compared to 32 percent at Guavate. Nine of the 10 species located at Cambalache have a predictable service life which ranges from 6 to 11 years, averaging 9 years. At Guavate 8 of the 10 species show a service life that ranges from 8 to 11 years, averaging 9.5 years.

Camasey blanco, hoja menuda, laurel geo, and pomarrosa are showing more failures than the other species. Within the limits of this treatment, this cannot be related to the absorption and penetration of the preserving oil.

For the same species given a cold-soak treatment with 5 percent pentachlorophenol and 50-50 creosote mix at both sites, the preservative absorptions and penetrations are about identical. However, there are 56 percent failures in the penta treatment and 36 percent failures in the creosote treated posts, suggesting that the creosote mix may be more effective.

Cold-soak in 10 percent pentachlorophenol in diesel oil (table 5)

These posts were treated butt down in the preservative solution. Some of the species had light to severe wood borer attack prior to the treatment. Test posts were 4 feet long with a top diameter of about 3 inches.

At Cambalache species retentions ranged from 2.1 to 15.1 pounds per cubic foot, averaging 5.9. Of those set at Toro Negro, retentions varied from 5.0 to 9.7 pounds per cubic foot and averaged 6.8 pounds per cubic foot. No penetration data are available for these tests.

Of 122 posts installed at Cambalache, 22 or 18 percent are serviceable after 15 years of ground contact; 99 or 81 percent have been destroyed by decay fungi; and only 1 post has been lost due to combined decay and termite attack. Of 89

posts installed at Toro Negro, 67 or 75 percent are serviceable; 22 or 25 percent have been destroyed by decay fungi. There are no failures attributable partially or wholly to termite attack.

For the same seven species located at both plots, there have been 77 percent failure at Cambalache and 32 percent loss at Toro Negro. Average preservative retentions are 5.9 and 6.7 pounds per cubic foot respectively.

For all the species at Cambalache, service life estimates range from 5 to 17 years, averaging about 12 years. Only 8 of the 16 species installed at Toro Negro have sufficient failures for predicting average life and this ranges from 13 to 20 years, averaging 17 years.

There are 13 replicated species at the Cambalache plots now having a predictable service life, one group treated by cold soaking with 5 percent pentachlorophenol and the other with 10 percent concentration. Those treated with the 5 percent concentration have an average service life of 6.2 years while those treated with the 10 percent concentration have an average service life of 11.9 years. It should be noted that average retention of preserving oils are respectively 3.5 and 6.6 pounds per cubic foot or more appropriately 0.18 and 0.66 pound of dry penta per cubic foot.

Many of the posts treated with 10 percent pentachlorophenol had mild to severe insect attack before treatment and this could account for the higher solution absorption. Individual posts of those species that had varying degrees of insect damage prior to treatment generally show higher preservative absorptions in the more severely attacked posts.

A large part of the higher retentions in the 10 percent treatment, however, can be attributed to the method of cold soaking. If we compare the retention of those six species treated with 10 percent pentachlorophenol, that were free of insect attack prior to treatment, with the same species preserved with 5 percent pentachlorophenol, we find that the average absorptions are respectively 6.2 and 3.8 pounds per cubic foot. The posts treated with the 10 percent solution were submerged butt down in a relatively deep tank and greater hydrostatic pressure could force a larger quantity of preservative into the wood than would be absorbed if submerged in a horizontal position. The use of this technique to increase absorption has been described by Walters (14), Walters and Meek (15), and Blew (5).

Except for uvilla and tortugo amarillo, the serviceability of all the species is most satisfactory. This vertical cold-soak technique appears to be adaptable to a wide choice of

species. It must be realized, however, that the pentachlorophenol consumption is almost four times greater than for the more conventional horizontal cold-soak treatment described above.

Hot-and-cold bath, 5 percent pentachlorophenol in diesel oil (table 6)

Retention by species ranged from 2.0 to 25.0 pounds per cubic foot, averaging 9.2 pounds. Side penetration is generally good, varying from 35 to 100 percent of the sapwood radius.

After 8 years of service only 45 out of 763 posts installed at Cambalache and Guavate have been destroyed. There were no losses attributable to termite attack alone. About one-third of these failures were in bambú. Average service life cannot as yet be predicted for most of these species, but such few failures do suggest a serviceability of at least 15 years.

Time in the hot-and-cold baths was varied considerably according to the treatability of each species and in some cases absorptions are excessive. Most of the longer schedules cannot be recommended for a commercial operation and more feasible cycles are now being developed.

Hot-and-cold bath, 50-50 creosote-diesel oil solution (table 7)

As for the same method using pentachlorophenol, widely different schedules were adopted. Species retentions varied from 5.4 to 13.1 pounds per cubic foot, averaging 8.5 pounds. Side penetration ranged from 59 to 100 percent of the sapwood radius.

Only 5 creosoted posts of 396 installed at Cambalache and Guavate have failed after 8 years of service. This compares with the 4 failures shown by the 10 matched species treated with 5 percent pentachlorophenol. These results indicate that both chemical formulations are having about the same effectiveness.

Average service life cannot as yet be predicted by the mortality curve. Nevertheless, we should expect a serviceability of at least 15 years.

Hot-and-cold bath, carbolineum (table 8)

Posts treated with carbolineum represent the oldest test installation under review in this report, and though the number of posts is very limited, results to date permit some definite conclusions. Posts installed in 1950 were 6 feet long and had top diameters that ranged from 3 to 5 inches; those set out in 1955 were 3- to 4-foot long stubs with top diameters of 5 to 6 inches.

Retention for the three species treated in 1950 ranged from 5 to 9 pounds per cubic foot with an irregular side penetration. The casuarina posts installed in 1944 have excessively high retentions, averaging 20 pounds per cubic foot, with a side penetration of about 1 inch or 30 percent of the sapwood radius.

There are no failures in the 1950 installations. Of six casuarina posts installed in 1944 there has been one failure, which indicates an average predicted service life of 32 years.

The excellent record of the eucalyptus and caimitillo posts strongly suggests that we can anticipate similar results from most of the species treated with pentachlorophenol or creosote using the hot-and-cold bath technique, and is a basis for our assumption that these posts should, conservatively, have an average service life of at least 15 years.

Double diffusion (table 9)

A. Tank treatments (T).--Dry salt retentions of Combination FC (sodium fluoride followed by copper sulfate) varied from 0.07 pound per cubic foot for mangle blanco to 0.60 pound per cubic foot for the eucalypt. Average retention for all species is 0.34 pound per cubic foot. Total salt concentration used in Combination CAC (copper sulfate followed by a mixture of sodium chromate and sodium arsenate) is about double that of Combination FC and retentions ranged from 0.28 pound per cubic foot for caimitillo to 1.44 pounds per cubic foot for almendra, averaging 0.76 pound.

Of 671 posts treated by Combination FC, there have been, after 7 years of service, 32 percent failures. Twenty of the 30 species located at Cambalache have sufficient failures for predicting an average service life of 7.7 years.

Of 685 treated with the Combination CAC, there have been 17 percent failures. Only 14 of the 30 species at Cambalache have a predictable service life, which is 8.5 years.

Penetration data are available only for posts treated with the Combination CAC salts and about 75 percent of the failures were in those species having fair or poor penetration.

For the same 6 species located at both Cambalache and Guavate and treated with Combinations FC and CAC there have been 35 percent removals at the former plot as compared to 22 percent at the latter.

B. Barrel or end diffusion treatments (B).--Groundline retentions of posts treated with Combination FC varied with species from 0.13 to 0.99 pound per cubic foot, averaging 0.66

pound. Posts treated with Combination CAC have dry salt retentions varying from 0.69 to 4.33 pounds per cubic foot, averaging 1.44 pounds.

Movement of the chemicals to the top of the posts by end diffusion was negligible. In almost all cases, the absorption in the tops is considerably less than 0.1 pound per cubic foot. Though not shown in table 9, a large number of the posts treated by the barrel method were classified non-serviceable due to severe decay in the tops and not because of failure at the groundline.

Of a total of 256 posts treated with Combination FC, 65 percent have failed after 7 years of service; compared to 46 percent failures in those 276 posts treated with Combination CAC.

All of the species treated with Combination FC have sufficient failures for predicting average service life. This ranges from 1.5 to 10.8 years, averaging 6.4 years. Twenty-four of the twenty-nine species treated with Combination CAC have a predictable service life which ranges from 2.1 to 10.8 years, averaging 7.2 years.

Optimum retentions of these water-borne preservatives, as applied to tropical hardwoods, are still not clearly defined. Minimum requirements should be at least those specified for the various salt combinations used to treat coniferous post species in a more temperate climate, i.e. 0.5 to 1.0 pound of dry salt per cubic foot (1). The tank treatment using the copper arsenate chromate combination appears to be most suitable as only 4 species (caimitillo, cassia de Siam, guamá, and maría) out of the 29 under evaluation have less than minimal retention. Species that show particular promise are those having a good to excellent penetration, as well, and they are:

achiotillo
almácigo
almendra
camasey blanco
eucalipto (robusta)
guaba
laurel geo
teca
tulipán africano
verde seco
yagrumo hembra
yagrumo macho

After 7 years of service these 12 species installed at Cambalache have about 13 percent removals. The remaining 17 species that had low chemical retention or poor to fair penetration, have about 20 percent removals to date. It is anticipated that as exposure continues there will be more obvious differences between these treatment levels.

CONCLUSIONS

Although most of the posts have been in service 8 years or less, several tentative conclusions may now be drawn:

1. Whether established in a coastal or mountain area, average service life of untreated posts is only 1.5 years, individual species varying from 0.4 to over 11 years. The longer life of some of the species can be attributed to the presence of a larger volume of durable heartwood.

2. Although termite attack may be locally severe, decay fungi cause most of the failures.

3. In all preservation treatments having sufficient removals upon which to base an estimate of average service life, posts established at the several high elevation plots have fewer failures than matched material placed in the low-land Cambalache plot.

4. Of the 55 species located at Cambalache and treated by cold soaking for 5 days in 5 percent pentachlorophenol dissolved in diesel oil, 53 have sufficient failures for predicting a service life of 3 to 12 years, averaging 6.8 years. Achiotillo, cacao motillo, caimitillo, caimitillo verde, and sabinón are the few species most receptive to this treatment and field results, to date, indicate that they will have an average service life substantially longer than 10 years.

5. For the same species given a 5-day cold-soak treatment with 5 percent pentachlorophenol and a similar treatment with 50-50 creosote-diesel oil, the preservative absorptions and penetrations are almost identical. However, the creosote mix appears to be more effective.

6. Posts treated with a 10 percent concentration of pentachlorophenol in diesel oil by cold soaking in a vertical position butt down for 5 days have, with the exception of uvilla and tortugo amarillo, an estimated average life of about 12 years at Cambalache. A comparison of matched species shows that vertical cold soaking, using a 10 percent preservative concentration, increases chemical absorption about fourfold over that obtainable with posts treated in a horizontal position using a 5 percent solution.

7. Hot-and-cold bath treatments using pentachlorophenol or creosote have, to date, only 50 failures out of 1,159 posts installed. Average service life cannot be predicted, but similar treatments using carbolineum indicate that the service

life should be about 15 years or more. In this treatment there are no differences, as yet, in effectiveness between the pentachlorophenol and creosote preserving oils.

8. Of 1,888 posts treated by double diffusion, regardless of method or chemical combination, 66 percent are serviceable after 7 years in the ground. Most of the failures were posts with only butts treated and little or no chemical absorption in the tops. The most promising double diffusion technique is the tank method using a 2-day soak in 10 percent copper sulfate followed by a 2-day soak in a mixture of 6.5 percent sodium arsenate and 6.5 percent sodium chromate. Species that are particularly responsive to this treatment are:

achiotillo
almácigo
almendra
camasey blanco
eucalipto (robusta)
guaba
laurel geo
teca
tulipán africano
verde seco
yagrumo hembra
yagrumo macho

Table 1.--Description of test plot sites

Item	Location			
	Cambalache	Guavate	Toro Negro	El Verde
Elevation (ft.)	100	2100	2900	1120
Soil	clay to sandy clay loam pH 5.9	clay pH 5.3	clay pH 5.1	clay pH 5.4
Geology	deposited from coastal materials	residual from volcanic rock	residual from volcanic rock	residual from volcanic rock
Temperature (°F.)				
mean coldest month	74.0	69.3	65.8	69.3
mean hottest month	80.4	75.9	72.1	76.1
mean annual	77.6	73.1	69.3	73.1
Rainfall (in.)				
Sept.-Nov.	16.0	17.3	37.6	29.4
Dec.-Feb.	16.4	11.2	13.4	13.5
Mar.-May	11.6	14.4	24.6	24.1
June-Aug.	12.5	39.7	23.8	32.0
mean annual	56.5	82.6	99.4	99.0

Table 2.--Condition of untreated control posts installed in the Cambalache (CA) and Guavate (GU) test plots, Puerto Rico after 8 years of service. Posts installed in April 1959

Species	Location	Posts in test	Condition of posts, April 1967				Total removed		Average life 1/
			Serviceable	Removed because of					
				Decay	Decay & termites	Termites			
		No.	No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	19	--	9	10	--	19	100	.9
Aguacatillo	CA	20	--	18	2	--	20	100	1.4
Almácigo	CA	20	--	18	2	--	20	100	.4
Almendra	CA	20	--	13	7	--	20	100	1.3
Ausubo	CA	20	--	8	11	1	20	100	1.9
Bambú	CA	20	--	17	3	--	20	100	1.4
"	GU	17	1	15	1	--	16	94	2.1
Cacao motillo	CA	20	--	6	14	--	20	100	1.4
Caimitillo verde	CA	20	--	15	5	--	20	100	1.8
Camasey jusillo	CA	19	--	12	7	--	19	100	3.3
Camasey blanco	CA	20	--	17	3	--	20	100	1.3
" "	GU	20	1	19	--	--	19	95	1.2
Caoba dominicana 2/	CA	20	1	10	9	--	19	95	2.1
Capá blanco	CA	17	7	5	5	--	10	59	6.9
Caracolillo	CA	19	--	12	7	--	19	100	1.7
Cassia de Siam	CA	20	--	14	6	--	20	100	1.0
Casuarina	CA	20	--	6	14	--	20	100	1.0
"	GU	20	--	19	1	--	20	100	1.5
Cieneguillo	CA	20	--	13	7	--	20	100	1.9
Cucubano	CA	20	--	10	10	--	20	100	1.2
Espino rubial	CA	19	--	9	10	--	19	100	.9
Eucalipto (robusta)	CA	20	--	6	13	--	20	100	1.4
Granadillo	CA	20	1	9	10	--	19	95	1.4
Guaba	CA	20	--	11	9	--	20	100	1.3
"	GU	18	--	18	--	--	18	100	1.4
Guamá	CA	19	--	11	8	--	19	100	1.5
"	GU	20	--	19	1	--	20	100	1.6
Guaraguao	CA	20	--	9	11	--	20	100	1.1
Hoja menuda	CA	20	--	10	10	--	20	100	1.4
" "	GU	20	--	18	2	--	20	100	1.8
Hueso blanco	CA	20	--	12	8	--	20	100	1.4
Jagüey	CA	20	--	13	7	--	20	100	1.1
Laurel avispillo	CA	20	--	10	10	--	20	100	.9
Laurel geo	CA	18	--	4	14	--	18	100	1.1
" "	GU	19	--	19	--	--	19	100	1.2
Mangle blanco	CA	20	--	3	13	4	20	100	1.0
" "	GU	20	--	18	2	--	20	100	1.3
Mangle colorado	CA	20	--	12	8	--	20	100	1.2
Mangle botón	CA	20	6	6	8	--	14	70	3.6
Mantequero	CA	19	--	3	16	--	19	100	.9
Manzanillo	CA	19	--	2	16	1	19	100	.9
María	CA	20	--	7	13	--	20	100	1.2
Maricao	CA	19	--	15	4	--	19	100	1.4
Masa	CA	20	--	6	13	1	20	100	1.2
Mesa	CA	20	--	11	9	--	20	100	1.4
Moca	CA	20	--	13	7	--	20	100	1.2
Moral	CA	20	--	11	9	--	20	100	.8
Muñeco	CA	17	--	8	9	--	17	100	.9
Negra lora	CA	20	--	10	10	--	20	100	1.8
Palo de gallina	CA	20	--	15	5	--	20	100	.8
Palo de matos	CA	20	--	7	13	--	20	100	1.0
Péndula	CA	14	--	7	7	--	14	100	1.2
Pomarrosa	CA	18	--	3	14	1	18	100	1.1
"	GU	20	--	19	1	--	20	100	1.2
Rabo de ratón	CA	20	--	12	8	--	20	100	.8
" " "	GU	20	--	20	--	--	20	100	.7
Retama 2/	CA	20	--	17	2	1	20	100	1.7
Tachuelo	CA	20	18	1	1	--	2	10	10.8
Roble	CA	20	--	15	5	--	20	100	3.0
"	GU	20	--	18	2	--	20	100	2.8
Tea	CA	20	20	--	--	--	--	--	--
Sabinón	CA	20	--	6	14	--	20	100	1.2
Tabonuco	CA	18	--	11	7	--	18	100	1.2
Teca	CA	20	--	10	10	--	20	100	1.4
Tulipán africano	CA	20	--	17	3	--	20	100	.9
Ucar	CA	17	--	16	1	--	17	100	3.5
Uvilla	CA	20	--	11	8	1	20	100	1.4
Verde seco 2/	CA	21	1	18	2	--	20	95	2.1
Yagrumo hembra	CA	17	--	12	5	--	17	100	.6
Yagrumo macho	CA	20	--	10	10	--	20	100	.8
Zarcilla	CA	19	--	19	--	--	19	100	2.9

1/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. When percentage of posts removed is less than 10 percent, no estimate on average life is given.

2/ Posts in service 7 years at time of last inspection.

Table 3.--Condition of round posts treated by cold soaking for 5 days in 5% pentachlorophenol dissolved in diesel oil after about 8 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Posts installed in April 1959

Species	Location	Posts in test	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, April 1967				Total removed		Average life 1/
			Min.	Max.	Av.			Serviceable	Removed because of					
									Decay	Decay & termites	Termites			
		No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	19	6.2	13.1	8.4	1.63	100	13	6	--	--	6	32	9.6
Aguacatillo	CA	20	.6	3.2	1.6	.10	7	3	15	2	--	17	85	4.4
Almácigo	CA	18	4.3	8.9	6.1	1.07	85	1	17	--	--	17	95	4.2
Almendra	CA	18	1.6	3.2	2.2	.33	34	1	14	3	--	17	95	6.6
Ausubo	CA	20	1.9	3.9	2.6	.52	36	7	5	7	1	13	65	7.8
Bambú	CA	20	--	--	--	--	--	3	17	--	--	17	85	6.3
Cacao motillo	CA	20	3.8	8.1	5.3	1.35	92	14	1	5	--	6	30	10.0
Caimitillo	CA	20	5.1	9.3	7.4	1.13	79	18	1	1	--	2	10	12.5
Caimitillo verde	CA	20	--	--	5.7	.64	46	19	1	--	--	1	5	--
Camasey blanco	CA	20	1.2	3.6	2.3	.10	8	9	9	2	--	11	55	8.3
" "	GU	20	1.6	3.0	2.4	.10	8	9	11	--	--	11	55	8.3
Camasey jusillo	CA	20	1.4	3.2	2.1	.10	8	13	3	4	--	7	35	9.4
Capá blanco	CA	20	1.7	6.4	2.6	.31	26	14	5	1	--	6	30	10.0
Caracolillo	CA	20	1.3	2.9	2.1	.42	28	4	12	3	1	16	80	7.3
Cassia de Siam	CA	20	3.1	6.6	4.8	.62	42	7	11	2	--	13	65	7.8
Casuarina	CA	20	3.9	8.4	5.6	.93	72	9	6	5	--	11	55	8.3
"	GU	20	3.7	7.5	5.4	.93	72	18	2	--	--	2	10	12.5
Cieneguillo	CA	20	.5	2.0	.8	.15	11	4	5	10	1	16	80	7.0
Cucubano	CA	20	1.8	3.6	2.5	.17	13	6	13	1	--	14	70	7.6
Espino rubial	CA	19	2.1	3.1	2.6	.19	17	--	15	4	--	19	100	2.7
Eucalipto (robusta)	CA	20	.9	3.9	2.1	.17	22	3	12	5	--	17	85	7.0
Granadillo	CA	19	2.1	5.9	3.1	.41	46	13	6	--	--	6	32	9.6
Guaba	CA	20	2.5	5.5	3.9	.25	20	4	13	3	--	16	80	7.0
"	GU	20	2.7	5.4	4.1	.25	20	6	14	--	--	14	70	7.5
Guamá	CA	20	2.0	6.9	3.4	.34	31	2	18	--	--	18	90	7.4
"	GU	20	1.8	6.7	3.6	.34	31	13	7	--	--	7	35	9.4
Guaraguao	CA	20	2.3	4.8	3.4	.97	79	7	13	--	--	13	65	7.8
Hoja menuda	CA	20	1.4	3.9	2.6	.16	13	11	2	7	--	9	45	8.8
" "	GU	20	1.8	3.5	2.7	.16	13	11	8	1	--	9	45	8.8
Hueso blanco	CA	20	1.1	2.5	1.9	.59	45	6	4	10	--	14	70	7.5
Jagüey	CA	20	1.9	5.6	2.6	.41	28	--	15	5	--	20	100	3.7
Laurel avispillo	CA	19	1.5	3.0	2.2	.53	41	--	12	6	1	19	100	3.6
Laurel geo	CA	21	3.0	7.4	5.0	.34	27	5	13	3	--	16	76	7.1
" "	GU	20	3.7	7.6	5.3	.34	27	4	16	--	--	16	80	7.4
Mangle blanco	CA	20	1.9	6.8	3.4	.59	52	8	6	6	--	12	60	8.0
" "	GU	20	2.3	5.3	3.4	.59	52	14	5	1	--	6	30	10.0
Mangle botón	CA	20	1.7	4.0	2.5	.48	44	13	5	2	--	7	35	9.4
Mangle colorado	CA	20	2.2	3.5	3.0	.73	60	2	7	10	1	18	90	4.5
Mantequero	CA	20	4.1	9.7	6.3	.70	50	2	10	8	--	18	90	4.2
Manzanillo	CA	18	5.1	8.1	6.2	.52	33	1	13	4	--	17	95	6.7
María	CA	20	2.2	6.4	4.1	.34	24	8	8	4	--	12	60	8.0
Maricao	CA	20	1.9	4.2	2.8	.32	22	5	7	8	--	15	75	7.3
Masa	CA	20	1.0	2.6	1.8	.20	16	--	3	12	5	20	100	3.4
Moca	CA	20	2.8	4.3	3.8	.89	69	6	11	3	--	14	70	7.5
Moral	CA	17	2.5	6.0	3.5	.29	28	3	9	4	1	14	83	4.3
Muñeco	CA	20	3.3	7.0	4.9	.52	40	4	12	4	--	16	80	7.0
Negra lora	CA	19	1.4	4.1	2.6	.06	5	3	11	5	--	16	84	7.1
Palo de gallina	CA	20	2.7	5.4	4.0	.14	10	1	15	3	1	19	95	6.0
Palo de matos	CA	20	2.2	5.4	3.1	.28	23	6	10	4	--	14	70	7.5
Péndula	CA	19	1.1	2.9	1.9	.20	14	14	4	2	--	6	30	10.0
Pomarrosa	CA	20	3.2	6.7	4.9	.31	22	2	8	10	--	18	90	6.0
"	GU	20	2.7	7.1	4.9	.31	22	8	11	1	--	12	60	8.0
Rabo de ratón	CA	20	2.8	6.2	4.6	.39	32	3	10	7	--	17	85	7.0
" " "	GU	20	3.2	7.0	4.4	.39	32	2	18	--	--	18	90	7.4
Roble	CA	20	3.3	5.7	4.3	.53	37	19	1	--	--	1	5	--
"	GU	19	3.7	5.9	4.7	.53	37	18	2	--	--	2	10	12.5
Sabinón	CA	20	6.7	13.6	10.1	.91	69	14	5	1	--	6	30	10.0
Tabonuco	CA	19	1.4	3.5	2.0	.12	8	1	7	9	2	18	95	3.8
Teca	CA	19	1.0	2.6	1.6	.50	51	4	10	4	1	15	79	5.9
Tulipán africano	CA	20	3.1	6.2	4.4	.19	17	5	14	1	--	15	75	6.0
Ucar	CA	19	1.0	2.2	1.5	.10	9	4	7	8	--	15	79	7.8
Uvilla	CA	20	2.1	5.4	3.5	.40	29	3	16	1	--	17	85	4.7
Yagrumo hembra	CA	19	2.1	6.1	4.1	.65	50	1	16	2	--	18	95	4.1
Yagrumo macho	CA	18	2.8	5.5	3.6	.81	56	--	15	3	--	18	100	3.4
Zarcilla	CA	20	.9	2.5	1.5	--	--	1	13	5	1	19	95	3.4

1/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 4.--Condition of round posts treated by cold soaking in 50% creosote - 50% diesel oil after about 8 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Treated posts installed in April 1959

Species	Location	Posts in test	Treating time	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, April 1967				Total removed		Average life 1/
				Min.	Max.	Av.			Serviceable	Removed because of					
										Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Camasey blanco	CA	20	120	.6	2.7	1.6	.14	11	8	11	1	--	12	60	8.0
" "	GU	20	120	.8	2.6	1.8	.14	11	7	13	--	--	13	65	7.8
Casuarina	CA	20	120	2.4	8.8	5.3	.81	55	17	3	--	--	3	15	11.4
"	GU	20	120	3.6	6.9	5.1	.81	55	19	1	--	--	1	5	--
Guaba	CA	20	168	2.4	6.3	4.2	.12	13	13	7	--	--	7	35	9.4
"	GU	19	168	3.4	5.6	4.2	.12	13	16	4	--	--	4	21	10.7
Guamá	CA	20	168	2.8	5.8	4.2	.71	53	16	4	--	--	4	20	10.6
"	GU	20	168	2.4	5.7	3.6	.71	53	17	3	--	--	3	15	11.4
Hoja menuda	CA	20	120	1.7	3.7	2.8	.14	11	3	10	7	--	17	85	5.8
" "	GU	20	120	1.9	4.0	2.8	.14	11	10	8	2	--	10	50	8.4
Laurel geo	CA	20	120	3.9	7.1	5.1	.22	16	12	8	--	--	8	40	9.2
" "	GU	19	120	3.6	7.8	5.3	.22	16	10	10	--	--	10	50	8.4
Mangle blanco	CA	20	120	1.8	5.3	3.2	.39	60	15	2	3	--	5	25	10.2
" "	GU	20	120	1.9	6.6	3.0	.39	60	16	3	1	--	4	20	10.6
Pomarrosa	CA	20	120	3.1	5.6	4.6	.31	22	1	10	9	--	19	95	6.3
"	GU	20	120	1.8	6.6	4.6	.31	22	7	13	--	--	13	65	7.8
Rabo de ratón	CA	20	120	4.0	6.1	4.9	.63	50	16	4	--	--	4	20	10.6
" " "	GU	19	120	4.1	6.9	5.4	.63	50	14	5	--	--	5	26	10.1
Roble	CA	20	120	3.0	6.2	4.5	.40	29	20	--	--	--	--	--	--
"	GU	20	120	3.0	6.1	4.6	.40	29	19	1	--	--	1	5	--

1/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 5.--Condition of round posts treated by cold soaking for 5 days in 10% pentachlorophenol dissolved in diesel oil after about 15 years of service. Cambalache and Toro Negro test plots, Puerto Rico. Posts installed in April 1952

Species	Posts in test	Retention of preservative			Insect attack prior to treatment[1]	Condition of posts, April 1967				Total removed		Average life[2]
		Min.	Max.	Av,		Serviceable	Removed because of					
							Decay	Decay & termites	Termites			
	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.		No.	No.	No.	No.	No.	Pct.	Yr.
CAMBALACHE TEST PLOT												
Abeyuelo	3	2.7	4.4	3.5	0	--	3	--	--	3	100	13.3
Acasia amarilla	9	4.6	12.0	7.3	L-H	3	6	--	--	6	67	14.2
Almácigo	8	12.9	18.7	15.1	0	--	8	--	--	8	100	8.9
Caimitillo de perro	10	2.1	6.2	4.6	0	--	10	--	--	10	100	11.5
Camasey de felpa	3	1.8	2.6	2.1	0	--	3	--	--	3	100	9.5
Cassia de Siam	10	3.3	7.2	4.3	0-H	1	9	--	--	9	90	14.0
Guácima	10	5.2	11.1	7.9	0	1	9	--	--	9	90	10.9
Guamá	4	4.2	9.1	6.2	0-H	--	4	--	--	4	100	10.5
Jagüey	4	3.8	4.2	4.0	0-L	1	2	1	--	3	75	12.8
Mangle blanco	7	9.0	13.7	12.2	M-H	2	5	--	--	5	72	11.7
Mangle botón	9	2.6	4.2	3.4	0	1	8	--	--	8	89	11.0
Moca	5	3.0	8.0	6.2	0-H	--	5	--	--	5	100	11.5
Moral	3	5.3	8.3	6.9	0	--	3	--	--	3	100	11.0
Péndula	3	1.4	3.3	2.4	0	1	2	--	--	2	67	11.0
Rabo de ratón	5	3.3	6.0	4.4	0	2	3	--	--	3	60	14.0
Roble	5	4.0	6.0	5.0	0	2	3	--	--	3	60	15.0
Tabloncillo	3	3.3	6.2	4.6	0	--	3	--	--	3	100	9.5
Tortugo amarillo	3	2.9	4.2	3.8	0	--	3	--	--	3	100	5.4
Uvilla	3	2.0	3.6	2.9	0-H	--	3	--	--	3	100	6.0
Yagrumo macho	5	7.0	10.2	8.7	0-H	2	3	--	--	3	60	15.0
Zarcilla	10	7.0	12.7	8.9	H	6	4	--	--	4	40	17.1
TORO NEGRO TEST PLOT												
Cacao motillo	3	7.0	8.6	7.9	L-M	3	--	--	--	--	--	--
Caimitillo (mesa)	10	3.7	9.3	7.2	0	10	--	--	--	--	--	--
Caimitillo verde	3	6.9	7.7	7.3	0	3	--	--	--	--	--	--
Eucalipto (patentinervis)	3	6.8	7.7	7.2	0	3	--	--	--	--	--	--
Eucalipto (robusta)	3	5.4	8.2	6.5	0	3	--	--	--	--	--	--
Guacimilla	9	5.3	8.7	6.7	0-L	2	7	--	--	7	78	13.4
Guaba	10	3.8	11.3	6.0	0-H	8	2	--	--	2	20	20.0
Guamá	5	3.4	10.8	7.6	L-H	4	1	--	--	1	20	20.0
Jagüey	4	4.2	6.7	5.6	M-H	1	3	--	--	3	75	14.8
María	4	6.8	7.2	7.0	0	4	--	--	--	--	--	--
Moca	5	4.1	7.0	5.7	0-H	2	3	--	--	3	60	15.0
Moral	5	6.0	9.5	8.0	0-M	3	2	--	--	2	40	17.2
Palo de matos	10	3.9	8.2	5.4	0-M	8	2	--	--	2	20	20.0
Rabo de ratón	6	3.5	7.7	5.0	0-H	4	2	--	--	2	33	18.2
Roble	5	4.5	6.8	5.7	0-H	5	--	--	--	--	--	--
Yagrumo macho	4	7.3	11.1	9.7	0-H	4	--	--	--	--	--	--

1/ 0 = none; L = light; M = medium; H = heavy.

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 6.--Condition of round posts treated by hot-and-cold bath using 5% pentachlorophenol dissolved in diesel oil after about 8 years of service. Cambalache (CA) amd Guavate (GU) test plots, Puerto Rico. Treated posts installed in April 1959

Species	Location	Posts in test	Treating time[1]	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, April 1967				Total removed		Average life[2]
				Min.	Max.	Av.			Serviceable	Removed because of: Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	19	1-1	9.5	18.9	15.6	1.50	100	19	--	--	--	--	--	--
Almendra	CA	19	1-3	7.4	12.8	9.5	1.40	100	13	6	--	--	6	32	9.8
Bambú	CA	20	2-1	--	--	--	--	--	4	16	--	--	16	80	7.0
Cacao motillo	CA	20	4-3	6.9	12.6	9.0	1.27	100	20	--	--	--	--	--	--
Caimitillo	CA	20	4-3	5.7	11.9	8.5	.96	82	20	--	--	--	--	--	--
Camasey blanco	CA	20	3-120	4.0	11.7	7.4	1.01	84	20	--	--	--	--	--	--
" "	GU	18	3-120	3.4	12.1	7.2	1.01	84	18	--	--	--	--	--	--
Camasey jusillo	CA	19	1-48	6.0	9.0	6.8	--	--	19	--	--	--	--	--	--
Cassia de Siam	CA	20	4-3	7.2	12.5	9.1	.53	42	20	--	--	--	--	--	--
Casuarina	CA	19	15-120	6.1	10.6	7.5	1.54	100	19	--	--	--	--	--	--
"	GU	20	15-120	6.3	10.5	7.8	1.54	100	20	--	--	--	--	--	--
Eucalipto (robusta)	CA	19	2-4	6.2	14.6	9.1	.84	100	16	3	--	--	3	16	11.6
Guaba	CA	20	3-5	6.1	14.3	8.9	.76	64	20	--	--	--	--	--	--
"	GU	20	3-5	6.7	14.0	9.8	.76	64	20	--	--	--	--	--	--
Guamá	CA	20	3-5	4.2	15.0	7.4	1.25	87	20	--	--	--	--	--	--
"	GU	20	3-5	4.5	13.1	8.4	1.25	87	19	1	--	--	1	5	--
Hoja menuda	CA	18	4-120	5.2	9.6	7.4	1.44	100	18	--	--	--	--	--	--
" "	GU	20	4-120	4.0	9.4	6.8	1.44	100	20	--	--	--	--	--	--
Laurel geo	CA	20	15-24	18.9	31.1	25.0	1.60	100	20	--	--	--	--	--	--
" "	GU	20	15-24	12.9	30.0	23.5	1.60	100	20	--	--	--	--	--	--
Mangle blanco	CA	20	5-120	2.9	9.0	5.2	.92	100	18	2	--	--	2	10	12.6
" "	GU	19	5-120	2.8	12.4	6.3	.92	100	18	1	--	--	1	5	--
Mangle botón	CA	19	2-10	4.2	6.9	5.2	1.30	100	19	--	--	--	--	--	--
María	CA	20	2-10	14.0	19.1	16.8	1.33	100	20	--	--	--	--	--	--
Moca	CA	20	2-10	3.7	12.7	7.0	1.15	82	20	--	--	--	--	--	--
Moral	CA	20	1-4	6.2	11.7	8.0	--	--	20	--	--	--	--	--	--
Péndula	CA	20	2-10	2.1	5.8	3.9	.57	41	20	--	--	--	--	--	--
Pomarrosa	CA	20	5-29	8.5	13.8	10.7	1.37	100	20	--	--	--	--	--	--
"	GU	20	5-29	8.2	13.1	10.4	1.37	100	20	--	--	--	--	--	--
Rabo de ratón	CA	20	4-12	8.5	18.2	12.2	1.25	100	20	--	--	--	--	--	--
" " "	GU	20	4-12	8.5	16.7	12.2	1.25	100	20	--	--	--	--	--	--
Roble	CA	20	15-26	6.4	16.5	11.4	1.31	100	20	--	--	--	--	--	--
"	GU	19	15-26	7.5	13.6	10.5	1.31	100	19	--	--	--	--	--	--
Teca	CA	20	2-120	2.1	7.0	4.1	.64	73	19	1	--	--	1	5	--
Tulipán africano	CA	18	1-3	4.6	11.2	9.4	--	--	17	1	--	--	1	6	--
Ucar	CA	19	3-120	1.3	3.4	2.0	.42	35	14	4	1	--	5	26	10.2
Uvilla	CA	19	4-3	2.8	11.8	5.2	1.42	97	15	2	2	--	4	21	10.7
Yagrumo macho	CA	19	2-4	8.0	15.7	11.4	1.57	100	16	3	--	--	3	16	11.6
Zarcilla	CA	20	3-120	1.6	3.3	2.3	--	--	18	2	--	--	2	10	12.6

1/ First number, time in hot bath; second number, time in cold bath.

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 7.--Condition of round posts treated by hot-and-cold bath using 50% creosote and 50% diesel oil after about 8 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Treated posts installed in April 1959

Species	Location	Posts in test	Treating time[1]	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, April 1967				Total removed		Average life[2]
				Min.	Max.	Av.			Serviceable	Removed because of: Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Camascy blanco	CA	20	4-120	3.1	10.6	6.6	.81	59	19	1	--	--	1	5	--
" "	GU	20	4-120	3.2	11.4	7.3	.81	59	20	--	--	--	--	--	--
Casuarina	CA	20	15-24	6.8	11.2	9.0	1.52	100	20	--	--	--	--	--	--
"	GU	20	15-24	7.2	10.9	9.0	1.52	100	20	--	--	--	--	--	--
Guaba	CA	20	3-8.5	5.8	14.0	10.1	1.06	74	20	--	--	--	--	--	-
"	GU	19	3-8.5	3.7	12.8	8.5	1.06	74	19	--	--	--	--	--	-
Guamá	CA	19	3-28	2.8	11.5	7.0	1.25	86	19	--	--	--	--	--	--
"	GU	20	3-28	3.7	12.1	7.4	1.25	86	20	--	--	--	--	--	--
Hoja menuda	CA	20	4-120	5.3	8.6	6.6	1.44	98	20	--	--	--	--	--	--
" "	GU	19	4-120	6.3	8.9	7.6	1.44	98	19	--	--	--	--	--	--
Laurel geo	CA	20	3-2	3.2	16.1	9.2	1.01	82	20	--	--	--	--	--	--
" "	GU	20	3-2	2.9	15.8	9.3	1.01	82	19	1	--	--	1	5	--
Mangle blanco	CA	20	15-120	3.1	13.8	5.4	.98	100	18	1	1	--	2	10	12.3
" "	GU	20	15-120	3.1	9.6	5.4	.98	100	19	1	--	--	1	5	--
Pomarrosa	CA	20	3-20	9.1	15.1	11.8	1.41	100	20	--	--	--	--	--	--
"	GU	20	3-20	9.2	13.3	11.0	1.41	100	20	--	--	--	--	--	--
Rabo de ratón	CA	19	3-2	8.7	15.7	11.7	1.36	100	19	--	--	--	--	--	--
" " "	GU	20	3-2	10.0	16.1	13.1	1.36	100	20	--	--	--	--	--	--
Roble	CA	20	3-4.5	3.9	12.8	7.6	.96	66	20	--	--	--	--	--	--
"	GU	20	3-4.5	3.9	10.5	6.6	.96	66	20	--	--	--	--	--	--

1/ First number, time in hot bath; second number, time in cold bath.
2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 8.--Condition of round posts treated by hot-and-cold bath using carbolineum. Toro Negro and Cambalache posts in service 17 years; El Verde posts in service 23 years

Species	Location	Posts in test	Treating time[1]	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, April 1967				Total removed		Average life[2]
				Min.	Max.	Av.			Serviceable	Removed because of: Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Casuarina	El Verde	6	6-16	17	23	20	3/4 - 1	30	5	1	--	--	1	17	32
Caimitillo	Cambalache	2	4-16	5.3	5.5	5.4	Irregular		2	--	--	--	--	--	--
"	Toro Negro	2	4-16	5.5	7.0	6.2	"		2	--	--	--	--	--	--
Eucalipto (patentinervis)	Cambalache	2	4-16	8.0	10.5	9.2	"		2	--	--	--	--	--	--
" "	Toro Negro	2	4-16	5.1	5.4	5.2	"		2	--	--	--	--	--	--
Eucalipto (robusta)	Cambalache	12	4-16	2.6	9.8	6.0	"		12	--	--	--	--	--	--
" "	Toro Negro	12	4-16	4.4	7.8	6.0	"		12	--	--	--	--	--	--

1/ First number, time in hot bath; second number, time in cold bath.
2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 9.--Condition of round posts treated by double diffusion after 7 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Posts installed in March 1960

Species	Location	Treatment	Treating time	Posts in test	Retention			Radial penetration by tank treatment (T-CAC) [1]	Condition of posts, April 1967				Total removed		Average life [2]
					Barrel		Tank average		Serviceable	Removed because of					
					Ground line	Top				Decay	Decay & termites	Termites			
			Days	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.		No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	T-FC [3]	3+3	20			.41		20	--	--	--	--	--	--
	CA	T-CAC [4]	2+2	19			.80	G	17	--	2	--	2	10	10.8
	CA	B-CAC [5]	2+2	11	1.06	trace			2	5	2	2	9	82	4.6
	CA	B-FC [6]	3+3	9	.69	.03			--	2	5	2	9	100	4.0
Almácigo	CA	T-FC	3+3	15			.43		4	11	--	--	11	73	6.5
	CA	T-CAC	2+2	20			.89	G	12	8	--	--	8	40	8.0
	CA	B-CAC	2+2	9	1.50	.03			1	3	1	4	8	90	6.2
	CA	B-FC	3+3	8	.57	.02			--	8	--	--	8	100	1.5
Almendra	CA	T-FC	4+4	20			.50		9	4	7	--	11	55	7.2
	CA	T-CAC	2+2	19			1.44	G	17	2	--	--	2	10	10.8
	CA	B-CAC	2+2	3	4.33	.02			1	2	--	--	2	66	6.8
	CA	B-FC	4+4	6	.85	.05			1	4	1	--	5	83	3.3
Bambú (retention based on volume of wall only)	CA	T-FC	3+3	21			.32		1	20	--	--	20	95	2.2
	GU	T-FC	3+3	18			.32		3	15	--	--	15	83	5.3
	CA	T-CAC	2+2	19			1.17	P	3	16	--	--	16	84	3.6
	GU	T-CAC	2+2	21			1.17	P	9	12	--	--	12	57	7.1
	CA	B-CAC	2+2	10	1.48	.03			--	10	--	--	10	100	2.1
	CA	B-FC	3+3	8	.69	.06			--	6	1	1	8	100	2.0
Cacao motillo	CA	T-FC	2+4	19			.22		19	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.63	F	19	1	--	--	1	5	--
	CA	B-CAC	2+2	10	1.07	.02			2	--	--	8	8	80	6.1
	CA	B-FC	2+4	11	.72	.01			4	1	--	6	7	63	6.9
Caimitillo	CA	T-FC	3+3	19			.27		16	2	1	--	3	16	10.0
	CA	T-CAC	2+2	20			.28	P	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.39	.01			6	--	--	4	4	40	8.0
	CA	B-FC	3+3	11	.46	.06			8	1	--	2	3	27	8.8
Camasey blanco	CA	T-FC	3+3	21			.56		12	8	1	--	9	43	7.9
	CA	T-CAC	2+2	19			1.29	C	19	--	--	--	--	--	--
	CA	B-CAC	2+2	9	1.20	.04			9	--	--	--	--	--	--
	CA	B-FC	3+3	10	.60	.03			5	2	3	--	5	50	7.4
Caoba dominicana	CA	T-FC	3+3	20			.32		20	--	--	--	--	--	--
	CA	B-FC	3+3	7	.55	.03			5	2	--	--	2	29	8.6
Cassia de Siam	CA	T-CAC	2+2	18			.41	G	18	--	--	--	--	--	--
	CA	B-CAC	2+2	12	1.41	.02			9	--	--	3	3	25	9.0
Casuarina	CA	T-FC	3+3	20			.19		4	12	4	--	16	80	6.9
	GU	T-FC	3+3	20			.19		12	7	1	--	8	40	8.0
	CA	T-CAC	2+2	19			.60	P	13	6	--	--	6	32	8.3
	GU	T-CAC	2+2	20			.60	P	15	5	--	--	5	25	9.0
	CA	B-CAC	2+2	11	1.42	.01			4	1	--	6	7	64	6.8
	CA	B-FC	3+3	10	.99	.05			7	1	1	1	3	30	8.6
Eucalipto (robusta)	CA	T-FC	3+3	17			.60		15	2	--	--	2	12	10.5
	CA	T-CAC	2+2	22			.81	G	21	1	--	--	1	5	--
	CA	B-CAC	2+2	10	1.18	.06			9	--	--	1	1	10	10.8
	CA	B-FC	3+3	10	.99	.05			--	4	1	5	10	100	6.0
Guaba	CA	T-FC	3+3	20			.26		19	1	--	--	1	5	--
	CA	T-CAC	2+2	20			.53	G	19	1	--	--	1	5	--
	CA	B-CAC	2+2	10	1.60	.01			8	--	1	1	2	20	9.4
	CA	B-FC	3+3	9	.52	.04			6	1	--	2	3	33	8.3
Guamá	CA	T-FC	3+3	18			.16		9	8	1	--	9	50	7.4
	GU	T-FC	3+3	19			.16		12	7	--	--	7	37	8.2
	CA	T-CAC	2+2	21			.43	P	20	1	--	--	1	5	--
	GU	T-CAC	2+2	20			.43	P	18	2	--	--	2	10	10.8
	CA	B-CAC	2+2	10	.90	.06			9	--	--	1	1	10	10.8
	CA	B-FC	3+3	12	.39	.05			9	--	--	3	3	25	9.0
Hoja menuda	CA	T-FC	3+3	21			.16		9	10	2	--	12	57	7.1
	CA	T-CAC	2+2	18			.48	F	17	1	--	--	1	6	--
	CA	B-CAC	2+2	9	1.44	.02			8	--	--	1	1	11	10.6
	CA	B-FC	3+3	9	.37	.04			4	1	1	3	5	55	7.2

1/ C = complete penetration; G = good penetration; F = fair penetration; P = poor penetration, less than 1/8 inch.

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed; where percentage of posts removed is less than 10 percent, no estimate on average life is given.

3/ T-FC: Tank treatment - 4 percent NaF and 7 percent $CuSO_4$.

4/ T-CAC: Tank treatment - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4.

5/ B-CAC: Posts upright in barrels (butt only) - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4.

6/ B-FC: Posts upright in barrels (butt only) - 4 percent NaF and 7 percent $CuSO_4$.

Table 9.--Condition of round posts treated by double diffusion after 7 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Posts installed in March 1960 (Continued)

Species	Location	Treatment	Treating time	Posts in test	Retention			Radial penetration by tank treatment (T-CAC) [1]	Condition of posts, April 1967				Total removed		Average life [2]
					Barrel		Tank average		Serviceable	Removed because of					
					Ground line	Top				Decay	Decay & termites	Termites			
			Days	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft		No.	No.	No.	No.	No.	Pct.	Yr.
Laurel avispillo	CA	T-FC [3]	3+3	20			.31		18	1	1	--	2	10	10.8
	CA	T-CAC [4]	2+2	20			1.24	F	19	1	--	--	1	5	--
	CA	B-CAC [5]	2+2	10	1.52	.04			1	4	--	5	9	90	6.3
	CA	B-FC [6]	3+3	11	.58	.09			1	2	3	5	10	91	6.6
Laurel geo	CA	T-FC	3+3	20			.24		19	1	--	--	1	5	--
	GU	T-FC	3+3	20			.24		19	1	--	--	1	5	--
	CA	T-CAC	2+2	19			.73	C	18	1	--	--	1	,5	--
	GU	T-CAC	2+2	19			.73	C	19	--	--	--	--	--	--
	CA	B-CAC	2+2	10	2.02	.07			9	1	--	--	1	10	10.8
	CA	B-FC	3+3	9	.91	.05			3	5	1	--	6	66	6.8
Mangle blanco	CA	T-FC	3+3	19			.07		11	2	6	--	8	42	7.8
	GU	T-FC	3+3	20			.07		18	2	--	--	2	10	10.8
	CA	T-CAC	2+2	19			.62	P	16	1	1	1	3	16	10.0
	GU	T-CAC	2+2	19			.62	P	18	--	--	1	1	5	--
	CA	B-CAC	2+2	11	.85	.01			--	3	2	6	11	100	3.9
	CA	B-FC	3+3	8	.13	.02			1	4	1	2	7	87	6.4
Mantequero	CA	T-FC	3+3	20			.30		13	6	1	--	7	35	8.2
	CA	T-CAC	2+2	17			.76	P	11	6	--	--	6	35	8.2
	CA	B-CAC	2+2	10	1.36	.02			2	2	--	6	8	80	6.1
	CA	B-FC	3+3	10	.56	.03			2	2	1	5	8	80	6.1
María	CA	T-FC	3+3	18			.32		18	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.45	F	19	1	--	--	1	5	--
	CA	B-CAC	2+2	10	.93	.05			7	1	--	2	3	30	8.6
Pomarrosa	CA	T-FC	3+3	21			.29		8	12	--	1	13	62	6.9
	CA	T-CAC	2+2	20			.59	F	8	11	1	--	12	60	7.0
	CA	B-CAC	2+2	10	1.79	.02			2	--	--	8	8	80	6.1
	CA	B-FC	3+3	9	.65	.02			1	2	1	5	8	89	6.1
Rabo de ratón	CA	T-FC	3+3	19			.20		10	5	4	--	9	47	7.6
	CA	T-CAC	2+2	20			.89	F	16	4	--	--	4	20	9.3
	CA	B-CAC	2+2	10	1.26	.02			6	2	1	1	4	40	8.0
	CA	B-FC	3+3	10	.55	.04			2	2	3	3	8	80	6.0
Retama	CA	T-FC	2+4	20			.33		17	3	--	--	3	15	10.0
	CA	T-CAC	2+2	20			.48	P	20	--	--	--	--	--	--
	CA	B-CAC	2+2	9	.83	.02			9	--	--	--	--	--	--
	CA	B-FC	2+4	9	.86	.10			4	2	2	1	5	55	7.2
Roble	CA	T-FC	3+3	19			.29		19	--	--	--	--	--	--
	GU	T-FC	3+3	20			.29		20	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.53	F	20	--	--	--	--	--	--
	GU	T-CAC	2+2	20			.53	F	20	--	--	--	--	--	--
	CA	B-CAC	2+2	9	2.28	.05			9	--	--	--	--	--	--
	CA	B-FC	3+3	10	.97	.09			9	1	--	--	1	10	10.8
Teca	CA	T-FC	3+3	18			.58		18	--	--	--	--	--	--
	CA	T-CAC	2+2	20			1.02	G	20	--	--	--	--	--	--
	CA	B-CAC	2+2	11	1.70	.06			10	1	--	--	1	9	--
	CA	B-FC	3+3	9	.77	.03			6	3	--	--	3	33	8.3
Tulipán africano	CA	T-FC	4+4	15			.53		4	10	--	1	11	73	6.5
	CA	T-CAC	2+2	18			1.24	C	13	4	--	1	5	28	8.7
	CA	B-CAC	2+2	7	1.90	.12			5	2	--	--	2	28	8.7
	CA	B-FC	4+4	6	.83	.05			4	2	--	--	2	33	8.3
Uvilla	CA	T-FC	3+3	20			.43		3	17	--	--	17	85	6.0
	CA	T-CAC	2+2	20			.56	P	9	11	--	--	11	55	7.2
	CA	B-CAC	2+2	8	.93	.02			5	2	--	1	3	37	8.2
	CA	B-FC	3+3	9	.58	.03			3	5	--	1	6	67	6.8
Verde seco	CA	T-FC	2+4	19			.45		18	1	--	--	1	5	--
	CA	T-CAC	2+2	20			.61	C	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.30	.02			10	--	--	--	--	--	--
	CA	B-FC	2+4	10	.64	.03			9	--	--	1	1	10	10.8
Yagrumo hembra	CA	T-FC	3+3	18			.42		13	4	1	--	5	28	8.7
	CA	T-CAC	2+2	20			.87	G	16	4	--	--	4	20	9.3
	CA	B-CAC	2+2	8	.69	.02			1	7	--	--	7	88	2.2
	CA	B-FC	3+3	6	.79	.03			--	4	1	1	6	100	2.1
Yagrumo macho	CA	T-FC	2+4	16			.47		13	3	--	--	3	19	9.4
	CA	T-CAC	2+2	19			1.10	C	13	6	--	--	6	32	8.4
	CA	B-CAC	2+2	9	1.41	.03			2	5	--	2	7	78	6.2
	CA	B-FC	2+4	10	.65	.02			1	6	1	2	9	90	2.2
Zarcilla	CA	T-FC	3+3	21			.34		10	11	--	--	11	52	7.3
	CA	T-CAC	2+2	20			.75	F	16	4	--	--	4	20	9.3
	CA	B-CAC	2+2	10	1.04	.01			2	1	4	3	8	80	6.1
	CA	B-FC	3+3	10	.53	.08			1	3	3	3	9	90	3.7

1/ C = complete penetration; G = good penetration; F = fair penetration; P = poor penetration, less than 1/8 inch.
2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts failed; where percentage of posts removed is less than 10 percent, no estimate on average life is given.
3/ T-FC: Tank treatment - 4 percent NaF and 7 percent $CuSO_4$.
4/ T-CAC: Tank treatment - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4.
5/ B-CAC: Posts upright in barrels (butt only) - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4.
6/ B-FC: Posts upright in barrels (butt only) - 4 percent NaF and 7 percent $CuSO_4$.

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APPENDIX

List of common and scientific names of species under review in this report

Abeyuelo	Colubrina arborescens (Mill.) Sarg.
Acacia amarilla	Albizzia lebbeck (L.) Benth.
Achiotillo	Alchornea latifolia Sw.
Aguacatillo	Meliosma herbertii Rolfe
Almácigo	Bursera simaruba (L.) Sarg.
Almendra	Terminalia catappa L.
Ausubo	Manilkara bidentata (A.DC.) Chev.
Bambú	Bambusa vulgaris Schrad.
Cacao motillo	Sloanea berteriana Choisy
Caimitillo (mesa)	Micropholis chrysophylloides Pierre
Caimitillo de perro	Chrysophyllum oliviforme L.
Caimitillo verde	Micropholis garcinifolia Pierre
Camasey blanco	Miconia laevigata (L) DC.
Camasey de felpa	Miconia prasina (Sw.) DC.
Camasey jusillo	Calycogonium squamulosum Cogn.
Caoba dominicana	Swietenia mahagoni Jacq.
Caoba hondureña	Swietenia macrophylla King
Capá blanco	Petitia domingensis Jacq.
Caracolillo	Homalium racemosum Jacq.
Cassia de Siam	Cassia siamea Lam.
Casuarina	Casuarina equisetifolia L.
Cieneguillo	Myrcia deflexa (Poir.) DC
Cucubano	Guettarda scabra (L.) Vent.
Espino rubial	Zanthoxylum martinicense (Lam.) DC.
Eucalipto (patentinervis)	Eucalyptus patentinervis R.T. Baker
Eucalipto (robusta)	Eucalyptus robusta J.A. Smith
Granadillo	Buchenavia capitata (Vahl.) Eichl.
Guaba	Inga vera Willd.
Guacimilla	Trema micrantha (L.) Blume
Guamá	Inga laurina (Sw.) Willd.
Guaraguao	Guarea trichilioides L.
Guácima	Guazuma ulmifolia Lam.
Hoja menuda	Myrcia coriacea DC.
Hueso blanco	Linociera domingensis (Lam.) Knobl.
Jagüey	Ficus laevigata Vahl.
Laurel avispillo	Nectandra coriacea (Sw.) Griseb.
Laurel geo	Ocotea leucoxylon (Sw.) Maza
Mangle blanco	Laguncularia racemosa (L.) Gaertn. f.
Mangle botón	Conocarpus erectus L.
Mangle colorado	Rhizophora mangle L.
Mantequero	Rapanea ferruginea (Ruiz & Pav.) Mez
Manzanillo	Sapium laurocerasus Desf.
María	Calophyllum brasiliense Camb.
Maricao	Byrsonima spicata (Cav.) Rich.
Masa	Tetragastris balsamifera (Sw.) Kuntze

Moca	Andira inermis (W. Wright) H.B.K.
Moral	Cordia sulcata DC.
Muñeco	Cordia borinquensis Urban
Negra lora	Matayba domingensis (D.S.) Radlk.
Palo de gallina	Alchorneopsis portoricensis Urban
Palo de matos	Ormosia krugii Urban
Péndula	Citharexylum fruticosum L.
Pomarrosa	Eugenia jambos L.
Rabo de ratón	Casearia arborea (L.C.Rich.) Urban
Retama	Sabinea florida (Vahl.) DC.
Roble	Tabebuia heterophylla (DC.) Brit.
Sabinón	Croton poecilanthus Urban
Tabloncillo	Sideroxylon portoricensis Urban
Tabonuco	Dacryodes excelsa Vahl.
Tachuelo	Pictetia aculeata (Vahl.) Urban
Tea	Amyris elemifera L.
Teca	Tectona grandis L. f.
Tortugo amarillo	Sideroxylon foetidissimum Jacq.
Tulipán africano	Spathodea campanulata Beauv.
Ucar	Bucida buceras L.
Uvilla	Coccoloba diversifolia Jacq.
Verde seco	Tetrazygia elaeagnoides (Sw.) DC.
Yagrumo hembra	Cecropia peltata L.
Yagrumo macho	Didymopanax morototoni (Aubl.) Dec. & Pl.
Zarcilla	Leucaena glauca (L.) Benth.

Chudnoff, M., R. S. Boone, and E. Goytía
1967. Preservative treatments and service life of fence posts in Puerto Rico. Inst. Trop. Forestry, U. S. Forest Serv. Res. Paper ITF-4.

Posts treated by four non-pressure techniques using five wood preservation chemicals have been set out at four test locations. About 6000 treated and non-treated control posts representing 70 species are under study. This report describes materials and methods used, chemical retentions and penetrations obtained, and reviews the condition of the posts up through the April 1967 inspection. Some installations date back to 1944, but most of the test posts have been in service for 8 years or less. Vertical cold-soaking, the hot-and-cold bath technique, and double diffusion salts applied by complete immersion are most effective and should be preferred over conventional cold-soaking or salt combinations applied by end diffusion.

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